Employing New Technologies to Advance Bean Breeding

A recently minted researcher in Zambia is utilizing new technologies developed with support from the Feed the Future Legume Innovation Lab to measure plant reactions related to photosynthesis—the process by which plants capture solar energy to generate food and energy for growth and development—in common bean to accelerate breeding toward improved varieties capable of producing better yields.


A member of Dr. Kamfwa's team takes photosynthesis readings of a bean plant using the MultispeQ.

Although improved varieties aren't new to Zambia, the challenge in bean breeding is time. Bean production in Zambia is severely limited, with national harvests of just 300 to 500 kg/ha leading to annual deficits of more than 11 million pounds. Beans provide a major source of income and affordable protein for many Zambians, 60 percent of whom live in poverty. The need to develop highly productive, robust, and sustainable bean crops is urgent and will only increase as climate change continues to affect farming systems and plant production negatively each successive year. Bean breeders need new tools to dramatically accelerate the processes in new ways.

Modern approaches to improving crops begin by studying a large library of plant varieties and identifying those gene variations that allow some varieties to perform better than others. For instance, some varieties perform better under drought, while others require less fertilizer or give a better yield. The genetic regions in which these variations are found are called QTLs (quantitative trait loci); once identified, a plant breeder can then cross various plants that contain several desirable QTLs to create *elite lines* that have multiple, high value traits.


Dr. Kamfwa's team takes readings throughout the entire field to account for as many variables within the scanning conditions as possible.

The key to harnessing this process is the ability to make very sensitive measurements of plant performance and then correlating these performances using computational methods to locate the genes responsible using genetic markers. Importantly, the characteristics—and related genes—that make one variety perform well in one location can actually decrease performance in another. For instance, a bean plant may be improved for high productivity in the presence of added nitrogen fertilizer but perform poorly in Africa where bacteria in the plant's roots provides nitrogen. Such variations arising from environmental differences make it critical to breed different varieties for each region and application. Unfortunately, developing such variations requires techniques have been expensive and difficult to use, especially for the developing world.

Enter the PhotosynQ Platform

The PhotosynQ project is changing that. Introduced by the Kramer Lab at Michigan State University (MSU) to circumvent these issues and bring cutting-edge plant sensors and data analytics to everyone, the platform includes an innovative handheld sensor, the MultispeQ, that when clamped on a leaf can reveal plant health and performance by measuring photosynthesis. The data is then wirelessly transmitted to the PhotosynQ internet cloud so it can be analyzed to identify the genetic regions that control particular performance characteristics that, in turn, direct the plant breeder on which plants to cross and which of the progeny are likely to perform better.

Dr. Kamfwa, center, examines the data uploaded to the PhotosynQ Platform with two of his team members.

Kelvin Kamfwa, a lecturer at the University of Zambia research station and Co-PI in the Feed the Future Legume Innovation Lab project *Improving Photosynthesis in Grain Legumes with New Plant Phenotyping Technologies* (lead PI David Kramer at MSU), has recently shown that the PhotosynQ platform works. Kamfwa's seven-member team has been able to map a series of QTLs in common beans that may improve photosynthesis under drought.

Kamfwa's team is conducting extensive field measurements of photosynthesis related to plant productivity and health using a library of varieties collected in different environments. They have used PhotosynQ to measure a dozen different traits in more than 7,000 plants. From this data, they calculated the QTL that correlated with improved photosynthetic performance under the specific agricultural conditions in Zambia. These loci can now be used to guide the breeding of the next generation of production seeds for potentially better yield and lower water requirements.

Improving photosynthesis requires selection for multiple traits simultaneously that increase yield and resilience to natural, fluctuating environmental conditions. Kamfwa has successfully incorporated this approach into his work—and the potential for advancing optimal seed to the planting fields will lead to improved crop yields for smallholder farmers and their families in Zambia.


Drs. Kamfwa and Kramer pose for a photo in the bean field Kamfwa is studying in Zambia.

David Kramer, whose Lab developed the PhotosynQ Platform, hopes to see the technology spread to advance plant breeding and improve crop yields throughout the developing world. "We aim to get these sophisticated tools used everywhere, so that local communities can more effectively improve their crops for their local conditions."